

ANNUAL REPORT

**SURVEYS AND STUDIES OF OKLAHOMA CRAYFISH AND THE GROTTO
SALAMANDER**

Elizabeth a. Bergey
Shane N. Jones
Dante B. Fenolio

Oklahoma Biological Survey
The University of Oklahoma

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PERFORMANCE REPORT

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Executive summary

Crayfish are one of the most imperiled groups of animals because many species have small ranges and, therefore, are especially vulnerable to habitat disturbance and competition from introduced non-native crayfish. One of the objectives of this project was to provide an updated survey of Oklahoma crayfish through (1) the identification of extensive crayfish material collected by Mr. Jimmie Pigg in the 1990's from throughout the state and (2) directed surveys in the southeastern corner of the state, where several rare crayfish species occur. Results from these surveys are:

- The identification of 82 samples from 30 counties from the Jimmie Pigg material.
- The collection and identification of 46 samples from McCurtain, LeFlore and Pushmataha Counties.
- Additional recent records for several rare species:
 - *Orconectes menae*: six sites in two counties
 - *Orconectes nana*: ten collections in three counties
 - *Orconectes deanae*: six collections in four counties
 - *Orconectes macrus*: two sites in one county
 - *Orconectes leptogonopodus*: five sites in one county
- No evidence that the endemic crayfish *Orconectes saxatilis* occurs in adjacent watersheds and no additional records of *Procambarus tenuis*.
- A potential new state record: *Procambarus dupratzi*.
- The addition of these records to the Oklahoma Natural Heritage database.
- One conference presentation, one submitted manuscript, and additional future publications on Oklahoma crayfishes.

The grotto salamander, *Typhlotriton spelaeus*, is found in caves in the Ozark Plateau. Studies were continued on the ecology and population biology of this species. Results from this work included:

- Additional observations of guano feeding and migration into the cave during the summer when bats are present, indicating the importance of bats to grotto salamanders.
- An experiment to test the growth of salamanders feeding on guano versus other foods was washed out twice by heavy rains, and time constraints prevented a third attempt.
- Summer surveys for marked salamanders continued and data useful in determining longevity and other population parameters were obtained.
- Three manuscripts were submitted for publication, and an additional manuscript is in progress. All manuscripts include the following statement: Financial support for this

publication was provided by the Oklahoma State Wildlife Grants under project T-11-P of the Oklahoma Department of Wildlife Conservation and the University of Oklahoma Biological Survey.

Project 1: Crayfish Distributional Surveys and Ecological Studies

Crayfish, along with freshwater mussels, share the dubious distinction of having a large percent of species with insecure futures. For crayfish, almost 50% of U.S. species are considered species of conservation concern (Taylor et al. 1996). The major threats to crayfish are habitat alteration or destruction, and the introduction of crayfish species, which are usually distributed into waterways by fishermen as released bait. An emerging threat is the addition of crayfish to the pet trade and the potential release of unwanted pets into new sites, including overseas locations. Crayfish have a high rate of endemism, and many species are known from only one state or watershed. Despite this endemism, crayfish have a low extinction rate; hence crayfishes are a group for which effective protection appears to be possible.

In addition to their use as bait and food by people and their recreation value to children, crayfish are important components in the food webs of streams, ponds and other aquatic habitats where they occur. Crayfish are long-lived (averaging 4-5 years), are very large relative to other invertebrates, and are omnivorous (consuming animals, plants, algae, and decaying material).

In Oklahoma, the crayfish fauna has been previously surveyed, but recent work has shown that the fauna is not completely known. Four new state records have been added since Hobb's 1989 checklist, bringing the number of species in Oklahoma to 28 (Taylor et al. 2004). The majority of this new information on crayfish distributions comes from recent efforts to identify a vast collection of material amassed between 1992 and 1997 by the late Mr. Jimmie Pigg.

In addition to new state records, identification of the Pigg material has contributed recent records for several rare crayfish, including most of the non-cave species on the Oklahoma Wildlife Species of Greatest Conservation Need (OWSGCN) (e.g., *Orconectes menae*, *O. nana*, and *Procambarus tenuis*). Additional records for these species and possibly other rare species are available in the unidentified material. Identification of this material is highly cost effective, in comparison to the cost of conducting a comparable large-scale field survey.

The Pigg material is extensive, but is not completely comprehensive. The collection sites form a coarse 'grid' across the state and directed surveys for rare crayfish are needed to supplement the Pigg collection to better update known rare crayfish distributions. With the exceptions of a directed survey for the rare crayfish *Orconectes saxatilis* (Robison 2001) and recent field collections by the Oklahoma Biological Survey, nearly all Oklahoma crayfish records are historic (older than 30 years). In comparison to

surrounding states, Oklahoma lags behind in the conservation ranking of crayfish (as evidenced by the large percent of S? or SNR ranks in Oklahoma Natural Heritage Inventory database). Current information for conservation planning is sorely needed.

Cave-dwelling crayfish in Oklahoma are difficult to census because they tend to occur distant from the cave openings. Surveys of cave fauna are being conducted as a separate project.

OBJECTIVES

1. Further identification of the Jimmie Pigg crayfish collection.
2. Conduct directed surveys for rare crayfish species in southeastern Oklahoma.
3. Study the biology of crayfish *Orconectes saxatilis*.

METHODS

Jimmie Pigg collection. Crayfish had been collected during the 1990s by Jimmie Pigg in conjunction with a water quality monitoring program at the Oklahoma Department of Environmental Quality. The program was based on monitoring fish populations, but crayfish were collected also but never identified. The collected crayfish have been housed at the Sam Noble Oklahoma Museum of Natural History (University of Oklahoma), the Illinois Natural History Survey, and the collection of Dr. Horton Hobbs III (Wittenberg University, Ohio).

Many of the collection at the Sam Noble Oklahoma Museum of Natural History had been identified in 2001-2002, prior to this grant. This material had added new records of species occurrences and contributed toward an updated checklist of the crayfish of Oklahoma (Taylor et al. 2004). The identification of the remainder of the collection was completed as part of this grant. In addition, samples on loan from the Illinois Natural History Survey (INHS) were identified. To reduce replication in identifying multiple samples from the same site, samples from new sites and/or locations where rare species were likely to occur were selected for processing.

Crayfish in 82 samples from a total of 30 counties were identified. Individual samples contained one to three species each. Collection sites are shown in Figure 1 and are listed in Appendix 1.

Field collections. The southeastern corner of Oklahoma was identified as an area that was under-collected, contained several rare species of crayfish, and was likely to support species not previously recorded from the state (Chris Taylor, personal communication). Most sampling occurred during the fall, winter, and spring because males in breeding form are most common during this period (examining reproductive males is the more reliable method for positively identifying many crayfish species).

Crayfish were collected at 46 sites during the five sampling trips that took place in January, March, April, May and July 2004. Sites at which no crayfish were caught are not included in this report. Most collections were made in McCurtain County.

Additional collections were in LeFlore and Pushmataha Counties. Sampling sites are shown in Figure 1 and are listed in Appendix 1.

Sampling included a combination of hand searching and netting, and seining. Burrowing crayfish are much more challenging to collect and a few collections included burrowing species whose burrows were excavated. Because the goal of the study was to determine the distribution of species, including rare species, collecting was limited to a few voucher specimens, usually a first-form breeding male, an immature male, a female, and a juvenile. Other crayfish were released at the capture site. Collected individuals were preserved in ethyl alcohol. Collections were labeled and collection data were entered into the crayfish field book.

Laboratory processing of samples: Crayfish were examined using a dissecting microscope for magnification. Identifications were based primarily on the illustrated checklist by Hobbs (1989), and a few questionable specimens were sent to Dr. Chris Taylor (Illinois Natural History Survey) for verification. Identification to species was not always possible, especially where collections contained only females and/or juveniles.

Identified crayfish were catalogued, placed in museum jars with new alcohol, and labeled. These samples have been returned to the Sam Noble Oklahoma Museum of Natural History, are still on loan from INHS, or are part of the crayfish collection at the Oklahoma Biological Survey.

RESULTS

Results of the surveys based on the Jimmy Pigg material and the field collections are shown in Tables 1 and 2, respectively.

The main targeted species were *Orconectes menae*, *O. nana*, *O. saxatilis*, and *Procambarus tenuis*. Collections also included several other uncommon species: *Orconectes deanae*, *O. macrus*, and *O. leptogonopodus*. A provisional new state record, *Procambarus dupratzi*, was collected, but a breeding-form male is needed to confirm the record. Each of these species is discussed below and Figure 2 shows collection locations.

Orconectes menae. This species occurs in stony streams of the Ouachita Mountains in Oklahoma and Arkansas. It is ranked S2 in Arkansas, where it is found in the Ouachita River watershed in Polk and Montgomery Counties (Williams 1954). It has not been ranked in Oklahoma, where it is known from LeFlore and McCurtain Counties in tributaries of the Little River which in turn is a tributary of the Red River (Williams 1954). The global rank of *O. menae* is G3. Taylor et al. (1996) consider *O. menae* to be a threatened species. We found the species in tributaries the Little/Mountain Fork watershed: two streams in LeFlore County (Rock Creek and Turkey Creek) and four streams in McCurtain County (Big Eagle Creek, Cooper Creek, Cow Creek, and Dry Panther Creek).

Orconectes nana. This small crayfish occurs in the Neosho (Hobbs 1989) and Illinois River watersheds in Oklahoma and was found in 11 of Jimmie Pigg's samples. The species is also found in Arkansas and is unranked in both Oklahoma and Arkansas. Its global rank is G3 and it is considered a species of special concern (Taylor et al. 1996). The Oklahoma sampling sites were the Illinois River main stem in Adair and Cherokee Counties, and one tributary of the Illinois River in each of Adair, Delaware, and Cherokee Counties.

Orconectes saxatilis. This species is endemic to Oklahoma and has a very limited range in the upper Kiamichi River watershed, where it is most common in Pigeon Creek, the type locality. It is ranked S1 and G1, and was considered as an endangered species by Taylor et. al. (1996). Recent work by Jones (2004) has increased its known range from that described by Robison (2001) and provided information on its ecology. *Orconectes saxatilis* is found primarily in cobble riffles, whereas the sympatric and larger *Orconectes palmeri longimanus* is generally found in pools (Jones 2004; Jones and Bergey, in review). *O. saxatilis* evidently aestivates in moist shallow burrows under boulders during part of the summer when surface water is limited, a trait that may allow it to exist in the upper Kiamichi River, but which may make it susceptible to habitat changes, including siltation associated with logging or burning, and hydrological changes that may occur if large volumes of water are piped from the watershed. *O. saxatilis* was not found in neighboring watersheds (which were part of this study), or at any other locations that we sampled. The range of *O. saxatilis* is described in Jones (2004) and remains restricted to a portion of the Kiamichi River watershed.

Procambarus tenuis. This species is found in Oklahoma and Arkansas, where its range is recorded to include the Arkansas, Ouachita and Red River watersheds in eastern Oklahoma and western Arkansas (Hobbs 1989). It is unranked in both states, but its global rank is G3 and it was considered to be a species of special concern by Taylor et al. (1996). *P. tenuis* was found sporadically in the upper Kiamichi watershed (Jones 2004), where it was always uncommon. *Procambarus tenuis* has not yet been found in any of the Jimmie Pigg samples (including those that were previously identified) or the recent field collections. The species had previously been found in a spring in Pushmataha County in 2001 and in Cucumber Creek in LeFlore County in 2002 (Oklahoma Biological Survey, unpublished data). *Procambarus tenuis* is apparently rare and its current distribution is poorly known.

Orconectes deanae. The Conchas crayfish was described in New Mexico, where it was considered an endemic species with a small range and ranked as G1. However, the species was recently discovered in Oklahoma (through earlier identification of a portion of the Jimmy Pigg material by Chris Taylor) and is now known to occur widely in the North Canadian River main stem and associated reservoirs. As a consequence of recognizing its greater range, *O. deanae* was reranked as G3. During this project, the original, but invalid description of this species was recognized in a Master's thesis (Dunlap 1951), in which it was named *Orconectes burrisi*. Unfortunately, the description was not published widely and, thus, is an invalid synonym. Several records of *O. deanae*

in the North Canadian River and one record in the Arkansas River in LeFlore County were found among the Jimmie Pigg material.

Orconectes macrus. The Neosho midget crayfish is known from the upper Arkansas River watershed, where it occurs at the junction of Kansas (ranked S1), Arkansas (not ranked), Missouri (S3?), and Oklahoma (not ranked). The species has a global rank of G4 and is considered currently stable (Taylor et al 1996). *O. macrus* was found in the Jimmie Pigg samples in Honey Creek and Spavinaw Creek in Delaware County.

Orconectes leptogonopodus. This crayfish is found in Oklahoma and in Arkansas, where it occurs in the Red River drainage in eastern Oklahoma (not ranked) and is more widespread in Arkansas (ranked as S3). It has a global rank of G4. We found *O. leptogonopodus* in 5 streams in McCurtain County.

Figure 1. Collection and sampling sites.

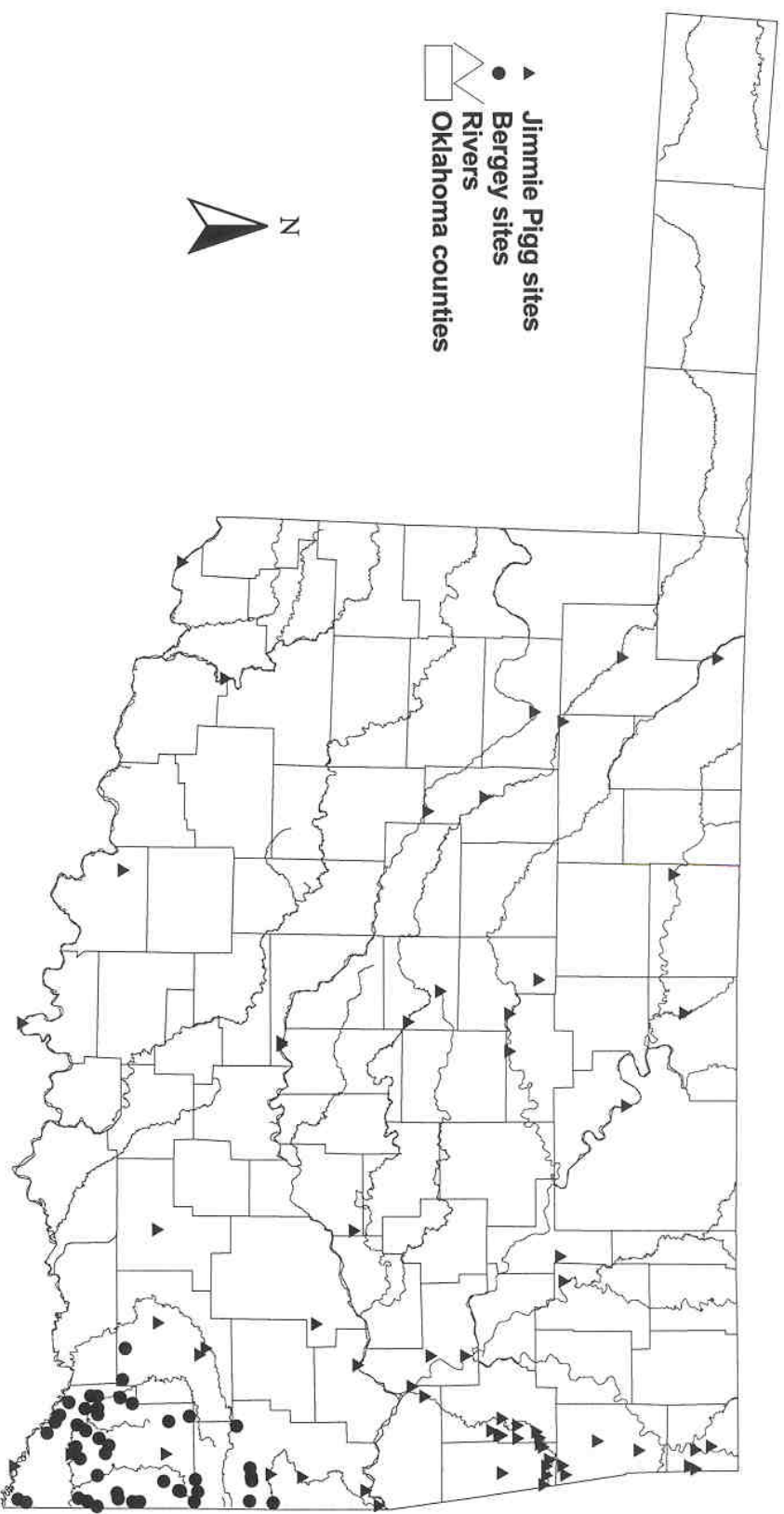
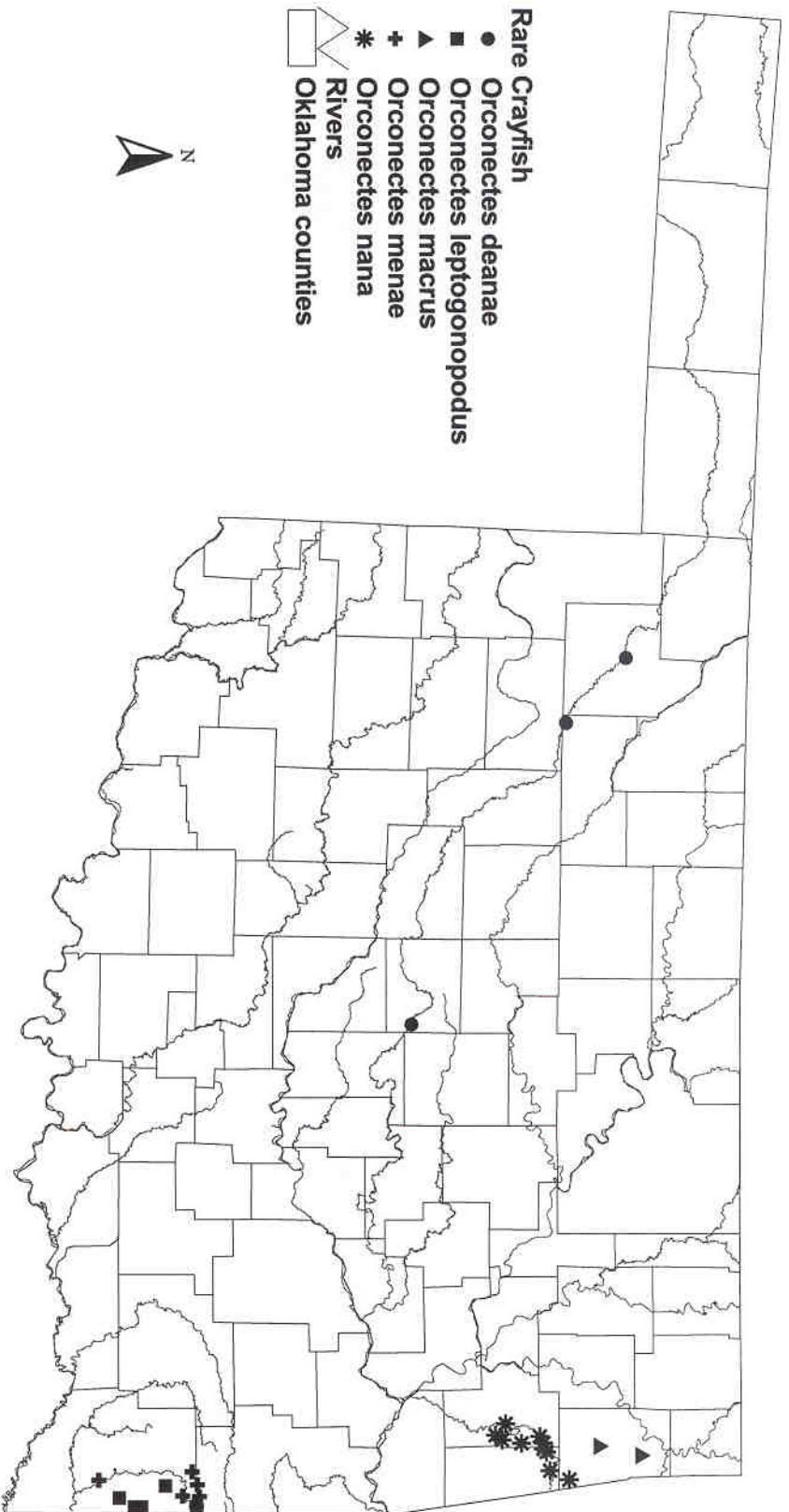


Figure 2. Collection sites for five rare species of Oklahoma crayfish.



Procambaus dupratzi. This species is not formerly known from Oklahoma and has been tentatively identified from three streams in McCurtain County, pending collection of a breeding-form male. *P. dupratzi* is known from Arkansas, Texas, and Louisiana and tributaries of the Red River are included in this range (Hobbs 1989). Although not a rare species, it's occurrence in Oklahoma is notable.

In addition to these rare and new species, a number of other species were identified among the samples. All of these records contribute to our knowledge of the current distribution of crayfish in Oklahoma, especially because most previous occurrence records were before 1980. These older, historical records are useful for examining temporal changes in distribution patterns, but have limited use in describing current distributions. These data are being used to update distribution patterns for crayfish, and have been added to the Oklahoma Natural Heritage Inventory database, where the information will be used to track species, assign state ranks, and respond to information requests. Data will be shared with collaborators working toward a checklist and description of Oklahoma crayfish.

Summary of project outputs:

1. Species records from 128 crayfish samples have been added to the crayfish database and are being added to the overall Heritage Inventory database.
2. These surveys contributed to the following presentations and papers:

Jones, S. H. and E. A. Bergey. 10 June 2004. Are all crayfish generalists? Habitat specificity in two sympatric species. Presentation at the annual meeting of the North American Benthological Society. Vancouver, B.C.

Jones, S. N. and E. A. Bergey. In review. A rare species in a rare habitat: habitat segregation in stream crayfishes. (submitted to Biological Conservation).

3. And will contribute to the following pending publications:
 - a. A publication on the distribution and identification of the crayfishes of Oklahoma Biological Survey
 - b. A note updating the recently published checklist of Oklahoma crayfish (Taylor et al. 2004), which will add *O. dupratzi*, if the identification can be verified.

Table 1. Summary of crayfish identified from Jimmie Pigg collections. Latitude/longitude of sites are in Appendix 1. Species of Conservation Need are bolded.

Collection #	Collection date	County	Site name	Species collected
ILL-16	25-Mar-95	Adair	Illinois River	Orconectes nana
ILL-103	18-May-96	Adair	Illinois River	<i>Orconectes neglectus</i>
ILL-37-38	25-Mar-98	Adair	Illinois River	Orconectes nana , <i>Orconectes neglectus</i>
ILL-8-9	25-May-95	Adair	Talhequah Hollow	<i>Orconectes meeki brevis?</i> , <i>Orconectes neglectus</i>
ILL-39-40	25-Mar-95	Adair	Tate Parrish Branch	Orconectes nana , <i>Orconectes neglectus</i>
ILL-12	25-Mar-95	Adair	Unnamed Creek	<i>Orconectes meeki brevis</i> , <i>Orconectes neglectus</i>
ILL-25	23-Oct-93	Atoka	Muddy Boggy Creek	<i>Orconectes difficilis</i> , <i>Orconectes palmeri longimanus</i>
C-467-468	5-Jun-97	Atoka	Muddy Boggy Creek	<i>Orconectes difficilis</i>
ILL-104	29-May-96	Beaver	Cimarron River	<i>Orconectes virilis</i>
ILL-97	22-Jul-93	Blaine	North Canadian River	<i>Orconectes nais</i>
ILL-64-65	14-Jul-92	Cherokee	Baron Fork River	<i>Orconectes neglectus</i>
ILL-77-78	9-Oct-93	Cherokee	Baron Fork River	<i>Orconectes nais</i> , <i>Orconectes neglectus</i>
ILL-109	19-May-95	Cherokee	Baron Fork River	<i>Orconectes neglectus</i>
ILL-17	25-Mar-95	Cherokee	Ceder Hollow	<i>Orconectes meeki brevis</i>
ILL-59-60	15-Jul-92	Cherokee	Illinois River	Orconectes nana , <i>Orconectes neglectus</i>
ILL-22-23	24-Mar-95	Cherokee	Illinois River	Orconectes nana , <i>Orconectes neglectus</i>
ILL-32-33	24-Mar-95	Cherokee	Illinois River	Orconectes nana , <i>Orconectes neglectus</i>
ILL-15	2-Apr-95	Cherokee	Illinois River	Orconectes nana
ILL-27-28	26-Mar-95	Cherokee	Unknown Creek	<i>Orconectes meeki brevis</i> , Orconectes nana
ILL-34-36	26-Mar-95	Cherokee	Wall Trip Branch	Orconectes nana , <i>Orconectes nais?</i> , <i>O. neglectus</i>
ILL-46	15-Jul-93	Choctaw	Red River	<i>Orconectes difficilis</i>
ILL-105	29-May-96	Cimarron	Cimarron River	<i>Procambarus simulans</i>
ILL-87-88	6-Apr-96	Delaware	Flint Creek	Orconectes nana , <i>Orconectes neglectus</i>
ILL-91-92	6-Apr-96	Delaware	Flint Creek	Orconectes nana , <i>Orconectes neglectus</i>
C-461-466	30-Jun-97	Delaware	Honey Creek	<i>Orconectes macrus</i> , <i>Orconectes neglectus</i> , <i>O. virilis</i>
C-469-471	9-Jul-96	Delaware	Spavinaw Creek	<i>Orconectes macrus</i> , <i>Orconectes neglectus</i> , <i>O. virilis?</i>
ILL-62	6-Jul-92	Dewey	North Canadian River	<i>Orconectes deanae</i>

Table 1. Continued

Collection #	Collection date	County	Site name	Species collected
ILL-42-43	5-Jul-94	Dewey	North Canadian River	<i>Orconectes deanae</i> , <i>O nais?</i>
ILL-111	28-May-96	Dewey	North Canadian River	<i>Orconectes deanae</i>
ILL-1-2	30-Jun-94	Dewey	South Canadian River	<i>Orconectes nais?</i> , <i>Procambarus curdi?</i>
ILL-72	4-Sep-93	Grant	Salt Fork of Arkansas River	<i>Orconectes nais</i>
ILL-98-99	2-Aug-93	Jackson	Prairie Dog Branch of Red R.	<i>Procambarus simulans</i>
ILL-84	3-Jul-95	Jackson	Prairie Dog Branch of Red R.	<i>Procambarus simulans</i>
ILL-73	3-Sep-93	Jefferson	Cow Creek	<i>Orconectes nais</i>
ILL-90	17-Sep-95	Kay	Chickasha River	<i>Orconectes virilis</i>
ILL-86	4-Jul-96	Kay	Chickasha River	<i>Orconectes virilis</i>
ILL-20	6-Jun-94	Leflore	Arkansas River	<i>Orconectes deanae</i>
ILL-21	6-Jun-94	Leflore	Arkansas River	<i>Orconectes nais</i>
ILL-61	22-Jul-92	Leflore	Poteau River	<i>Orconectes neglectus</i>
ILL-61	22-Jul-92	Leflore	Poteau River	<i>Orconectes palmeri longimanus</i>
ILL-24	16-Oct-93	Leflore	Poteau River	<i>Orconectes palmeri longimanus</i>
ILL-29	16-Oct-93	Leflore	Poteau River	<i>Orconectes palmeri longimanus</i>
ILL-68	5-Aug-92	Logan	Cimarron River	<i>Orconectes nais</i>
ILL-74	25-Apr-93	Logan	Cimarron River	<i>Orconectes nais</i>
ILL-19	3-Oct-93	Love	Red River	<i>Orconectes nais</i>
ILL-95-96	2-Jun-95	Love	Red River	<i>Orconectes nais?</i> , <i>Procambarus simulans</i>
ILL-4-5	16-Oct-93	McCurtain	Little River	<i>Orconectes acutus</i> , <i>Orconectes palmeri longimanus</i>
ILL-85	15-Oct-95	McCurtain	Little River	<i>Orconectes palmeri longimanus</i>
ILL-14	16-Oct-93	McCurtain	Lukfala Creek	<i>Orconectes palmeri longimanus</i>
ILL-49	27-Jul-94	McCurtain	Red River	<i>Procambarus acutus</i>
ILL-45	14-Jun-94	Muskogee	Arkansas River	<i>Orconectes nais</i>
ILL-82-83	1-Oct-95	Muskogee	Arkansas River	<i>Orconectes difficilis</i> , <i>Orconectes nais</i>
ILL-10	6-Jun-94	Muskogee	Canadian River	<i>Orconectes difficilis</i>
ILL-44	26-Jul-93	Muskogee	Weber Falls	<i>Orconectes nais</i>
ILL-75	28-Sep-93	Oklahoma	Deep Fork River	<i>Orconectes nais</i>

Table 1. Continued

Collection #	Collection date	County	Site name	Species collected
ILL-80	22-Jun-94	Oklahoma	Deep Fork River	<i>Orconectes nais</i>
ILL-69-70	10-Aug-93	Oklahoma	North Canadian River	<i>Orconectes deanae</i> , <i>Orconectes nais</i>
ILL-51-52	22-Jun-94	Oklahoma	North Canadian River	<i>Orconectes deanae</i> , <i>Orconectes nais</i>
ILL-81	24-Sep-95	Oklahoma	South Canadian River	<i>Orconectes nais</i>
ILL-18	25-Mar-95	Osage	Arkansas River	<i>Orconectes virilis</i>
ILL-94	8-Oct-95	Osage	Arkansas River	<i>Orconectes virilis</i>
ILL-107-8, 110	3-Jun-96	Ottawa	Brush Roark Creek	<i>Orconectes neglectus</i>
ILL-67	15-Jul-92	Ottawa	Spring River	<i>Orconectes nais</i>
ILL-47-48	18-Jul-94	Ottawa	Spring River	<i>Orconectes neglectus</i> , <i>Orconectes virilis</i>
ILL-101	3-Jun-96	Ottawa	Sycamore Creek	<i>Orconectes neglectus</i>
ILL-71	25-Sep-93	Payne	Cimarron River	<i>Orconectes nais</i>
ILL-93	13-Jun-94	Payne	Cimarron River	<i>Orconectes nais</i>
ILL-41	3-Aug-94	Payne	Cimarron River	<i>Orconectes nais</i>
ILL-63	20-Jul-92	Pittsburg	Featherson Creek	<i>Orconectes palmeri longimanus</i>
ILL-3	17-Sep-94	Pottawatomie	South Canadian River	<i>Orconectes nais</i>
ILL-50	27-Jul-94	Pushmataha	Kiamichi River	<i>Orconectes palmeri longimanus</i>
ILL-89	16-Oct-95	Pushmataha	Kiamichi River	<i>Orconectes palmeri longimanus</i>
ILL-31	8-Jun-94	Pushmataha	Lake Clayton	<i>Procambarus acutus</i>
ILL-100	5-Jun-96	Rogers	Bird Creek	<i>Orconectes nais</i>
ILL-106	5-Jun-96	Rogers	Verdigris River	<i>Orconectes virilis</i>
ILL-66	16-Jul-92	Sequoyah	Illinois River	<i>Orconectes neglectus</i>
ILL-79	10-Sep-93	Tillman	North fork of Red River	<i>Orconectes nais</i>
ILL-76	2-Oct-93	Tillman	North fork of Red River	<i>Orconectes nais</i>
ILL-6-7	24-Oct-93	Tulsa	Arkansas River	<i>Orconectes virilis</i> , <i>Procambarus acutus</i>
ILL-11	19-Sep-93	Woodward	North Canadian River	unidentified
ILL-30	11-Sep-94	Woodward	North Canadian River	<i>Orconectes deanae</i>
ILL-102	29-May-96	Woodward	North Canadian River	<i>Procambarus acutus</i>

Table 2. Summary of crayfish identified from directed field collections. Latitude/longitude of sites are in Appendix 1. Species of Conservation Need are bolded.

Collection#	Collection date	County	Site name	Species collected
CRW-04-21	18-Mar-04	LeFlore	Big Creek?	<i>Orconectes palmeri longimanus</i>
CRW-04-17	17-Mar-04	LeFlore	Bohannon Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-20	18-Mar-04	LeFlore	Folzsell Branch	<i>Orconectes palmeri longimanus</i>
CRW-04-22	18-Mar-04	LeFlore	Loving Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-18	18-Mar-04	LeFlore	Red Lick Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-13	17-Mar-04	LeFlore	Rock Crk	Orconectes menae , <i>Orconectes palmeri longimanus</i>
CRW-04-19	18-Mar-04	LeFlore	Shawnee Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-15	17-Mar-04	LeFlore	Turkey Crk	Orconectes menae , <i>Orconectes palmeri longimanus</i>
CRW-04-37	17-Jul-04	McCurtain	Ash Crk	<i>Orconectes leptogonopodus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-10	25-Jan-04	McCurtain	Big Branch	<i>Procambarus acutus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-42	17-Jul-04	McCurtain	Big Eagle Crk	Orconectes menae , <i>Orconectes palmeri longimanus</i>
CRW-04-39	17-Jul-04	McCurtain	Big Hudson Crk	<i>Orconectes leptogonopodus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-09	25-Jan-04	McCurtain	Boktuklo Crk	<i>Procambarus acutus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-24	03-Apr-04	McCurtain	Buck Crk	<i>Procambarus acutus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-38	17-Jul-04	McCurtain	Bull Crk	<i>Orconectes leptogonopodus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-05	24-Jan-04	McCurtain	Buzzard Creek	<i>Orconectes palmeri longimanus</i>
CRW-04-31	11-May-04	McCurtain	Cooper Crk	Orconectes menae , <i>Orconectes palmeri longimanus</i>
CRW-04-32	12-May-04	McCurtain	Courthouse Crk	<i>Procambarus acutus</i>
CRW-04-16	17-Mar-04	McCurtain	Cow Crk	<i>O. leptogonoodus</i> , Orconectes menae , <i>O. palmeri longimanus</i>
CRW-04-03	24-Jan-04	McCurtain	Cypress Creek	<i>Procambarus acutus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-41	17-Jul-04	McCurtain	Dry Panther Crk	Orconectes menae , <i>Orconectes palmeri longimanus</i>
CRW-04-33	12-May-04	McCurtain	Holly Crk	<i>Procambarus acutus</i>
CRW-04-04	24-Jan-04	McCurtain	Horse Head Crk	<i>Procambarus acutus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-29	11-May-04	McCurtain	Little River	<i>Orconectes palmeri longimanus</i>
CRW-04-44	18-Jul-04	McCurtain	Long Branch	<i>Orconectes palmeri longimanus</i>
CRW-04-46	18-Jul-04	McCurtain	Long Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-45	18-Jul-04	McCurtain	Luktata Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-28	11-May-04	McCurtain	Martin Crk	<i>Orconectes palmeri longimanus</i> , <i>Procambarus dupratzi?</i>

Table 2. Continued

Collection#	Collection date	County	Site name	Species collected
CRW-04-26	03-Apr-04	McCurtain	McKinney Crk	<i>Procambarus acutus</i>
CRW-04-40	17-Jul-04	McCurtain	Mud Lick Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-36	17-Jul-04	McCurtain	Pero Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-25	03-Apr-04	McCurtain	Ponka Bok Crk	unidentified
CRW-04-34	17-Jul-04	McCurtain	Ponka Bok Crk	<i>Procambarus acutus</i>
CRW-04-23	03-Apr-04	McCurtain	Rock Crk	<i>Orconectes nais?</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-35	17-Jul-04	McCurtain	Rock Crk	<i>Orconectes leptogonopodus</i> , <i>Orconectes palmeri longimanus</i>
CRW-04-01	24-Jan-04	McCurtain	Stevens Crk	<i>Procambarus acutus</i> , <i>Procambarus dupratzi?</i>
CRW-04-08	25-Jan-04	McCurtain	unnamed pond	<i>Procambarus acutus</i>
CRW-04-27	03-Apr-04	McCurtain	Walnut Crk	unidentified
CRW-04-07	24-Jan-04	McCurtain	Waterhole Creek	<i>Procambarus acutus</i>
CRW-04-43	17-Jul-04	McCurtain	West Fork	<i>Orconectes palmeri longimanus</i>
CRW-04-02	24-Jan-04	McCurtain	White Oak Crk	<i>Procambarus acutus</i> , <i>Procambarus dupratzi?</i>
CRW-04-06	24-Jan-04	McCurtain	Whitegrass Crk	<i>Procambarus acutus</i> , <i>Procambarus simulans?</i>
CRW-04-14	02-Apr-04	McCurtain	Whitegrass Crk	<i>Procambarus gracilis</i>
CRW-04-30	11-May-04	McCurtain	Yashoo Crk	<i>Orconectes palmeri longimanus</i>
CRW-04-12	25-Jan-04	Pushmataha	Frazier Crk	unidentified
CRW-04-11	25-Jan-04	Pushmataha	Turkey Crk	<i>Procambarus acutus</i> , <i>Orconectes palmeri longimanus</i>

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Appendix 1. Locations of collection and sampling sites.

Jimmy Pigg collections

Collection # ¹	County	Site name	Latitude ²	Longitude ²
C-461-466	Delaware	Honey Creek	36.546712	94.746346
C-467-468	Atoka	Muddy Boggy Creek	34.352799	96.014113
C-469-471	Delaware	Spavinaw Creek	36.358178	94.800353
ILL-1-2	Dewey	South Canadian River	36.051161	98.964276
ILL-3	Pottawatomie	South Canadian River	34.920332	97.045202
ILL-4-5	McCurtain	Little River	34.381981	94.759107
ILL-6-7	Tulsa	Arkansas River	35.253582	96.007942
ILL-8-9	Adair	Talhequah Hollow	36.139687	94.699232
ILL-10	Muskogee	Canadian River	35.268113	95.247420
ILL-11	Woodward	North Canadian River	36.442171	99.290712
ILL-12-13	Adair	Unnamed Creek	36.125594	94.610619
ILL-14	McCurtain	Lukfala Creek	33.975418	94.765674
ILL-15	Cherokee	Illinois River	35.995098	94.824124
ILL-16	Adair	Illinois River	36.111012	94.770583
ILL-17	Cherokee	Ceder Hollow	35.995059	94.895339
ILL-18	Osage	Arkansas River	36.499759	96.719409
ILL-19	Love	Red River	33.730286	97.152191
ILL-20-21	Leflore	Arkansas River	35.296209	94.540070
ILL-22-23	Cherokee	Illinois River	36.081790	94.859910
ILL-24	Leflore	Poteau River	35.354030	94.451666
ILL-25-26	Atoka	Muddy Boggy Creek	34.352759	95.491864
ILL-27-28	Cherokee	Unknown Creek	35.877897	94.869696
ILL-29	Leflore	Poteau River	34.862201	94.637378
ILL-30	Woodward	North Canadian River	36.442171	99.290712
ILL-31	Pushmataha	Lake Clayton	34.543309	95.313559
ILL-32-33	Cherokee	Illinois River	36.096379	94.824028
ILL-34-36	Cherokee	Wall Trip Branch	35.908112	94.842078
ILL-37-38	Adair	Illinois River	36.096456	94.788368
ILL-39-40	Adair	Tate Parrish Branch	36.125514	94.663917
ILL-41	Payne	Cimarron River	35.963666	97.024264
ILL-42-43	Dewey	North Canadian River	36.180411	98.911814
ILL-44	Muskogee	Weber Falls	35.602509	95.295715
ILL-45	Muskogee	Arkansas River	35.762258	95.295970
ILL-46	Choctaw	Red River		
ILL-47-48	Ottawa	Spring River	36.878451	94.761324
ILL-49	McCurtain	Red River	33.685851	94.702907
ILL-50	Pushmataha	Kiamichi River	34.572315	95.348567
ILL-51-52	Oklahoma	North Canadian River	35.500191	97.185642
ILL-61	Leflore	Poteau River	34.862201	94.637378
ILL-59-60	Cherokee	Illinois River	35.926176	94.935657
ILL-61	Leflore	Poteau River	34.862201	94.637378
ILL-62	Dewey	North Canadian River	36.180411	98.911814

Appendix 1. Continued

Collection # ¹	County	Site name	Latitude ²	Longitude ²
ILL-63	Pittsburg	Featherson Creek	35.080280	95.481173
ILL-64-65	Cherokee	Baron Fork River	35.922616	94.842080
ILL-66	Sequoyah	Illinois River	35.573446	95.065042
ILL-67	Ottawa	Spring River	36.805807	94.743125
ILL-68	Logan	Cimarron River	35.963791	97.238432
ILL-69-70	Oklahoma	North Canadian River	35.500191	97.185642
ILL-71	Payne	Cimarron River	35.963666	97.024264
ILL-72	Grant	Salt Fork of Arkansas R.	36.702348	98.046698
ILL-73	Jefferson	Cow Creek	34.180526	98.008538
ILL-74	Logan	Cimarron River	36.094113	97.434350
ILL-75	Oklahoma	Deep Fork River	35.645497	97.362759
ILL-76	Tillman	North fork of Red River	34.630826	99.097351
ILL-77-78	Cherokee	Baron Fork River	35.922738	94.627958
ILL-79	Tillman	North fork of Red River	34.630826	99.097351
ILL-80	Oklahoma	Deep Fork River	35.645497	97.362759
ILL-81	Oklahoma	South Canadian River	35.573214	98.375604
ILL-82-83	Muskogee	Arkansas River	35.514650	95.123670
ILL-84	Jackson	Prairie Dog Br. of Red R.	34.414579	99.734692
ILL-85	McCurtain	Little River	33.946333	94.765614
ILL-86	Kay	Chickasha River	36.760509	97.255761
ILL-87-88	Delaware	Flint Creek	36.212443	94.610363
ILL-89	Pushmataha	Kiamichi River	34.572315	95.348567
ILL-90	Kay	Chickasha River	36.760509	97.255761
ILL-91-92	Delaware	Flint Creek	36.197887	94.664063
ILL-93	Payne	Cimarron River	35.963666	97.024264
ILL-94	Osage	Arkansas River	36.499759	96.719409
ILL-95-96	Love	Red River	33.730286	97.152191
ILL-97	Blaine	North Canadian River	35.834032	98.463779
ILL-98	Jackson	Prairie Dog Br of Red R.	34.414579	99.734692
ILL-99	Jackson	Prairie Dog Br of Red R.	34.414579	99.734692
ILL-100	Rogers	Bird Creek	36.198796	95.860046
ILL-101	Ottawa	Sycamore Creek	36.805781	94.634987
ILL-102	Woodward	North Canadian River	36.877577	99.303610
ILL-103	Adair	Illinois River	36.111094	94.556844
ILL-104	Beaver	Cimarron River	35.007402	94.620272
ILL-105	Cimarron	Cimarron River	34.920332	97.062719
ILL-106	Rogers	Verdigris River	36.213179	95.717495
ILL-109	Cherokee	Baron Fork River	35.922616	94.842080
ILL-107-8,110	Ottawa	Brush Roark Creek	36.776853	94.652633
ILL-111	Dewey	North Canadian River	36.180411	98.911814

¹ C = Collections deposited at the Sam Noble Oklahoma Museum of Natural History; ILL = Collections on loan from the Illinois Natural History Survey

² Latitude and longitude was converted from township, range, and section, using the section center

Appendix 1. Continued

Directed field collections

Collection # ³	County	Site name	Latitude ⁴	Longitude ⁴
CRW-04-01	McCurtain	Stevens Crk	34.06829	95.08720
CRW-04-02	McCurtain	White Oak Crk	34.03997	95.08710
CRW-04-03	McCurtain	Cypress Creek	34.06993	95.01925
CRW-04-04	McCurtain	Horse Head Crk	34.07025	94.98424
CRW-04-05	McCurtain	Buzzard Creek	33.93930	95.05333
CRW-04-06	McCurtain	Whitegrass Crk	33.89563	94.98373
CRW-04-07	McCurtain	Waterhole Creek		
CRW-04-08	McCurtain	unnamed pond	33.83760	94.88421
CRW-04-09	McCurtain	Boktuklo Crk	34.07493	94.85191
CRW-04-10	McCurtain	Big Branch	39.17439	95.07665
CRW-04-11	Pushmataha	Turkey Crk	34.18605	95.17643
CRW-04-12	Pushmataha	Frazier Crk	34.19917	95.35040
CRW-04-13	LeFlore	Rock Crk	34.51161	94.61635
CRW-04-14	McCurtain	Whitegrass Crk	33.87494	94.94674
CRW-04-15	LeFlore	Turkey Crk	34.52133	94.54700
CRW-04-16	McCurtain	Cow Crk	34.50677	94.49362
CRW-04-17	LeFlore	Bohannon Crk	34.70583	94.91032
CRW-04-18	LeFlore	Red Lick Crk	34.76503	94.67780
CRW-04-19	LeFlore	Shawnee Crk	34.76789	94.62682
CRW-04-20	LeFlore	Folzsell Branch	34.77209	94.60542
CRW-04-21	LeFlore	Big Creek?	34.75982	94.49077
CRW-04-22	LeFlore	Loving Crk	34.86674	94.48093
CRW-04-23	McCurtain	Rock Crk	34.05955	94.47504
CRW-04-24	McCurtain	Buck Crk	34.01517	94.50464
CRW-04-25	McCurtain	Ponka Bok Crk	33.97544	94.52383
CRW-04-26	McCurtain	McKinney Crk	33.73596	94.50525
CRW-04-27	McCurtain	Walnut Crk	33.69725	94.52089
CRW-04-28	McCurtain	Martin Crk	34.01184	95.01772
CRW-04-29	McCurtain	Little River	33.97440	94.92915
CRW-04-30	McCurtain	Yashoo Crk	33.98735	94.74270
CRW-04-31	McCurtain	Cooper Crk	34.06450	94.64561
CRW-04-32	McCurtain	Courthouse Crk	34.01529	94.89600
CRW-04-33	McCurtain	Holly Crk	33.96812	94.80432
CRW-04-34	McCurtain	Ponka Bok Crk	33.97544	94.52383
CRW-04-35	McCurtain	Rock Crk	34.15398	94.54758
CRW-04-36	McCurtain	Pero Crk	34.15705	94.51728
CRW-04-37	McCurtain	Ash Crk	34.22408	94.49759
CRW-04-38	McCurtain	Bull Crk	34.25439	94.49747
CRW-04-39	McCurtain	Big Hudson Crk	34.36696	94.61024
CRW-04-40	McCurtain	Mud Lick Crk	34.43531	94.55684
CRW-04-41	McCurtain	Dry Panther Crk	34.44398	94.55394
CRW-04-42	McCurtain	Big Eagle Crk	34.48996	94.16846
CRW-04-43	McCurtain	West Fork	34.39563	94.94195

Appendix 1. Continued

Collection # ³	County	Site name	Latitude ⁴	Longitude ⁴
CRW-04-44	McCurtain	Long Branch	34.10148	96.76681
CRW-04-45	McCurtain	Luktata Crk	34.12021	94.81466
CRW-04-46	McCurtain	Long Crk	34.22945	95.04486

³ CRW collections are located at the Oklahoma Biological Survey at the University of Oklahoma

⁴ Latitude and longitude are direct GPS readings

Project 2: Grotto Salamander Ecological Study

The grotto salamander *Typhlotriton spelaeus* is a cave-dwelling salamander found in the Ozark Plateau and occurs in Oklahoma, Arkansas, Missouri, and Kansas. This species is ranked S3 in Oklahoma and G4 for its range. Unlike many cave-dwelling salamanders, the grotto salamander retains a biphasic life cycle with aquatic larvae and terrestrial adults. Although there are ongoing surveys for this and other species found in Ozark Plateau caves, there is little information on the ecology and population biology of this species. Such data would be useful in conservation planning.

OBJECTIVE

Study the biology of the grotto salamander *Typhlotriton spelaeus*.

Specifically, these studies were to:

1. Provide information needed to conserve this species; e.g., elucidate the relationship between grotto salamanders and cave-dwelling bats; especially the importance of bat guano to salamander diets.
2. Fine-tune the population estimate for the grotto salamander and validate initial results on seasonal use of caves by these salamanders.

PROGRESS

Research on the Grotto Salamander, *Typhlotriton spelaeus*, in the Ozark Plateaus Ecoregion was continued during the year.

The importance of bat guano to salamanders. It was established that the salamanders in the study cave (January-Stansberry Cave, Delaware Co., OK) were directly and intentionally consuming fresh guano from the endangered colonial bat, *Myotis grisescens*. Several observations of this behavior were made during the spring of 2004. An experiment was designed to determine whether *T. spelaeus* larvae could demonstrate growth in mass and length when fed a sole diet of fresh bat guano. After the experiment was started within the cave in May 2004, a rain-induced flood washed out the experiment. The experiment was reassembled in the last days of May, with modifications to reduce possible raccoon predation, and was again washed out of the cave through a second flooding event in late June 2004. With more heavy rains predicted after the second wash-out, it was determined that the wet spring months of 2004 would effectively prevent completion of the experiment in that season.

The design of the study required that the in-cave experiment be started at the onset of inhabitation of the cave by colonial bats (roughly May of each year). This allows enough time to follow growth in these slow-growing salamanders. Should funding be available, the experiment may be attempted again in the spring of 2005, in the hope that 2005's

spring will be more similar to the spring months of 2000-2003, when there were no major flooding events.

Population estimates and seasonal use of caves. This objective involved the continuation of monthly surveys at the study site to look for marked individuals from the marking period of 2001-2003. Visits to the cave produced six marked individuals and those data were recorded. Recaptures of marked individuals and the establishment of longevity in this species can play an important role in future conservation efforts. We would like to continue summer surveys of the population to check for marked individuals. Because we have the initial records for all individuals that were marked within the system, we can use recaptures to create projections of maximum age, age classes within the system, and even mortality rates. As the study increases in duration, the accuracy of these estimations will increase. In addition, the pattern of an almost ten-fold increase in encounter rates with salamanders in the main rooms of the cave during the summer months, relative to winter months when the bats are not present in the system, was validated for a third year. This important data is being incorporated into a manuscript covering the population ecology of the grotto salamander.

Publication of results. We have submitted three papers from the overall study of this system so far:

(1) Graening, G.O., Fenolio, D.B., Hobbs III, H.H., Jones, S., Slay, M.E., McGinnis, S.R. and Stout, J.F. Range extension and status update of the Oklahoma cave crayfish, *Cambarus tartarus* (Decapoda: Cambaridae), endemic to three cave streams in Oklahoma. Submitted to *The Southwestern Naturalist* in February 2004.

(2) Fenolio, D.B., Graening, G.O., and Stout, J.F. Seasonal movement pattern of Pickerel frogs (*Rana palustris*) in an Ozark cave and ecological implications supported by stable isotope evidence. Submitted to *The Southwestern Naturalist* in August 2004.

(3) Fenolio, D.B., Graening, G.O., and Stout, J.F. The first observations of coprophagy in a cave-adapted salamander. Submitted to *Nature* in October 2004.

In addition to these submissions, a fourth manuscript is in preparation:

Fenolio, D.B., Collier, B., Graening, G.O., and Stout, J.F. Population ecology of the Ozark blind cave salamander, *Typhlotriton spelaeus*, in the Ozarks of Oklahoma.

Prepared by: _____
Elizabeth A. Bergey

Date: _____

Approved by: _____
Harold E. Namminga
Federal Aid/Research Coordinator